PATENT SPECIFICATION

933,936

933,936

DRAWINGS ATTACHED.

Date of Application and filing Complete Specification: *Dec. 22, 1960.* *No. 44121/60.*

Application made in Germany (No. N17675 III/50c) on Dec. 22, 1959.

Complete Specification Published: Aug. 14, 1963.

Index at Acceptance:—**Class 23,** P(6B:8C), P10B2(A3:B:F).

International Classification:—B04b, c.

COMPLETE SPECIFICATION.

Improvements or or relating to Centrifugal Dust Separator Assemblies.

I, WILLY NEUMANN, of 26 Höhenweg, Wilhelmsfeld/Odenwald, Germany, of German nationality, do hereby declare the invention, for which I pray that a patent may be granted to me, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The invention relates to a novel centrifugal dust separator assembly which operates on the "eddy sink" principle and the dust extraction efficiency of which, according to measurements of dust extraction efficiency with a standardised air filter testing dust which is used for testing air filters for internal combustion engines and has the following composition as regards particle sizes:

0 — 5μ	12± 2%
5 — 10μ	12± 3%
10 — 20μ	14± 3%
20 — 40μ	23± 3%
40 — 80μ	30± 3%
80 — 200μ	9± 3%

is equivalent in practice to the dust extraction efficiency of good air filters, but the complicated and time-consuming maintenance of these filters, for example of oil-moistened metal air filters, is obviated.

In connection with ventilation plants in rooms or internal combustion engines, where the impurities are of atmospheric nature, for example blowing sand or road dust, the dust separated out from the air by the centrifugal separators according to the invention can be blown directly into the atmosphere by the centrifugal dust separator assembly according to the invention, whereby completely maintenance-free operation is possible.

As is known, with filter plants, for example with oil-moistened air filters which serve for cleaning the air for combustion of engines, considerable engine wear can be caused because of inefficient maintenance of these filters.

These disadvantages are overcome according to the invention.

The dust-extraction devices according to the invention are especially suitable for separating out radio-active dust (so-called atomic dust), for example in connection with vehicles which must be used in areas contaminated by atomic dust. Vehicles of this type are of course provided externally with a screen against atomic dust, but hitherto the cooling and combustion air necessary for the engines had to be drawn through air filters connected in front of the engine. The respiratory air for the crew of the vehicle was formerly purified in the same manner.

The dust retained by the filter forms a source of radio-active radiation and leads to damage to the health of the vehicle crew. Furthermore, cleansing of the contaminated filters also involves danger.

When using the centrifugal dust separator assembly according to the invention, the formation of sources of radiation in the vehicle are avoided or at least very substantially reduced because of dust extraction, since the atomic dust which is present in the contaminated area is immediately blown into the atmosphere again, so that accumulation of radio-active dust in the vehicle is scarcely possible.

With the centrifugal dust separator assembly according to the invention, the dusts separated out can, at will, be constantly discharged into the atmosphere or can be collected in a container which is to be emptied at intervals.

Centrifugal dust separators are known *per se* in which the air to be purified enters a cylindrical separating chamber tangentially and the purified air discharges axially, the tangential inlet consisting of a plurality of inlet openings arranged concentrically around the pure gas outlet pipe, the separating chamber having connected thereto a dust-collecting hopper which if necessary is connected to the conduit of a fan.

A centrifugal separator group is also known in the art which consists of a plurality of parallel-connected centrifugal separators arranged in line with a common initial gas distribution chamber and a common dust-collecting chamber the separate centrifugal separators being fitted on a common clean gas discharge duct and projecting into the dust collecting chamber.

The centrifugal separators known in the art have hitherto normally been made of sheet metal.

With the hitherto usual method of manufacturing separator elements from sheet metal, the manufacturing tolerances of the dimensions had to be kept very narrow and the surface properties of the air-guiding surfaces in the air-inlet and in the vortex chamber had to be kept very smooth and as far as possible polished, so that the air friction on the air-guiding surfaces is as small as possible in order to reduce the air vortex formation by which the dust separation is very greatly influenced. However, when the separator elements are made from sheet metal the necessary strict tolerances with the required surface quality cannot be produced at economical costs when manufacturing large numbers of units.

According to the present invention, a centrifugal dust separator assembly includes a number of elements each comprising a cylindrical vortex chamber with an approximately tangential dirty air inlet, in the form of a distributor similar to a turbine wheel and an axial clean air outlet, and with connected, separate or joint dust collecting containers, the distributor and vortex chamber being made as a die casting.

As regards the distributor manufactured as a die casting according to the invention and which is in the form of a turbine wheel open around its curved side, the air-guiding ducts of the distributor are defined by the top cover of the turbine wheel, its blades, and a centering ring. The centering ring in this case serves both for centering the distributor and vortex chamber and for forming the air-guiding ducts of the distributor.

According to the constructional form of the dust separator according to the invention which is shown in Figure 1, each vortex chamber has associated therewith a dust-collecting container into which the dust is conveyed through a dust outlet slot by the eddy sink in the dust collecting container.

According to a constructional form of the dust separator according to the invention as shown in Figure 2, several separator elements are assembled to form a group, the elements ejecting the dust into a common dust container.

With the separator groups known in the art and consisting of several separator elements with a common dust collecting container, the dust-extraction efficiency was substantially lower than the dust-extraction efficiency of separators having a separate dust collecting container.

The reason for this phenomenon is partially to be attributed to the fact that the separator elements made of sheet metal, because of the necessarily high manufacturing tolerances, differ to a greater or lesser degree from one another as regards the cross-section of the inlet apparatus and the diameter of the vortex chamber, and also as regards the surface quality of the air-guiding duct and the centering of the vortex chamber with the inlet apparatus, whereby the peripheral speeds of the vortexes in the vortex chambers are different.

Moreover, the air and dust admission to the separator elements when arranged in a group is different according to the position of the air-extraction ducts in the dust collecting housing, whereby the rotational speed of the vortex in the separator elements is unfavourably influenced.

With a greater admission of air to a separator element, the vortex speed increases, while this speed falls with a greater dust admission, because the mass of the dust must be accelerated by the vortex and this causes a braking of the peripheral speed of the vortex.

The vortex with a high peripheral speed produces a greater back pressure at the dust outlet slot to the collecting container than the slow vortex, the greater back pressure being partially balanced out through the dust outlet slot of an element with a slow vortex and having a lower back pressure and at least obstructs, if it does not completely prevent, the exit of dust from this element.

If the dust cannot be completely ejected from the vortex chamber, the dust of the air stream from the separator element is supplied again to the clean air stream, the overall outcome of which is that the separation efficiency of the group separator with a common dust collecting container is lowered relatively to the separation efficiency of the separator with a separate collecting container.

With uniform air and dust admission, the rotational speed of the vortex in the separator elements according to the invention is the same, because of the narrow limits of tolerance and the same surface quality of the elements.

According to the invention, in order to compensate for the back pressure in the dust outlet slot with different rotational speeds of the vortex with group separators, owing to differential air and dust admission to the elements, the pressure difference between the vortex centre and the dust outlet slot is used. The subatmospheric pressure at the

bottom of the vortex chamber and of the vortex centre is 2—3 times greater than the subatmospheric pressure at the dust outlet slot, according to the speed of rotation of the vortex.

With a subatmospheric pressure at the dust outlet slot of about 30 mm. water column, the subatmospheric pressure of the vortex centre at the bottom of the separator element is between 60 and 90 mm. water column.

The centrifugal dust separator according to the invention can consist of one separator element or a group of several separator elements.

According to the invention, with group separators having a common dust collecting container, the base of the vortex chamber is formed in the centre with a small hole (pressure-equalising hole); by means of this hole, the dust collecting container communicates with the vortex chamber, so that the greater subatmospheric pressure axially of the vortex centre reduces the back pressure at the dust outlet slot which is produced by the vortex. Because of this step, the dust outlet slots to the collecting chamber can no longer be influenced with a differential rotational speed of the vortex in the separator elements for the dust expulsion.

Through the middle hole in the base of the vortex chamber, and by the subatmospheric pressure in the vortex centre, a small stream of air is extracted by suction from the dust container into the vortex chamber, the said stream being charged with dust from the dust collecting container; some of the dust extracted at the vortex centre is projected from the said centre into the main vortex again and is again conveyed by the latter into the dust collecting container. Some of the dust which is sucked back rises in the vortex centre to the air outlet union and into the centrifugal separator, whereby the separation efficiency of the separator is impaired. In order that the deleterious effect on the separation efficiency is kept within tenable limits, the central hole in the base of the vortex chamber must be as small as possible. It has been shown by practical tests that the ratio between the cross-sections of the dust expulsion slot and the central hole should be 5:1. If the central hole is smaller than $^1/_5$ of the cross-section of the expulsion slot, the central hole can become clogged with a large accumulation of dust, whereby the functioning of the separator is impaired.

With a cross-sectional ratio of 5:1, the dust-extraction efficiency of the separator falls by about 2% as compared with a separator without a pressure-equalising hole and with a separate dust collecting container.

The decrease in the dust extraction efficiency can be further reduced by the compensating hole at the base of the vortex chamber being covered by a guide element for the dust-containing air, this element conveying the dust-laden air stream drawn from the dust collecting container almost radially into the vortex chamber, whereby the major part of the dust is blown into a more effective zone of the main vortex and is taken up by the latter. With this arrangement, the dust extraction efficiency of the separator only falls by about 1%.

The best possible dust extraction efficiency of the separator element according to the invention with a pressure-equalising hole can be produced by a filter, for example a sintered metal filter, being connected before the pressure-equalising hole in the dust container. In order to obtain a longest possible operative life of the separator element, the filter must be designed to be as large as possible, provided this is permitted by the size of the dust collecting container.

The dust extraction efficiency of the separator element with a filter connected in front of the pressure equalising hole is practically equal to the dust extraction efficiency of the separator element with a separate dust collecting container.

Another possible constructional form of a group centrifugal separator with the full separation efficiency of separators having a separate dust collecting container consists according to the invention in that the dust discharged from the vortex chamber by the vortex is drawn through a dust discharge duct disposed tangentially at the base of the said chamber. The dust discharge ducts of the separator elements are in this case connected to a dust collecting pipe and are drawn off by means of a suction fan or ejector.

If a plurality of separator elements are connected to a dust collecting pipe, the air carrying the dust in the dust discharge duct must as far as possible have a constant velocity, so that the dust is not able to be precipitated into the ducts or the collecting pipe and thus clog the pipes.

For the purpose of keeping the suction air velocity constant, nozzle-like diaphragms are provided in the connections of the dust discharge ducts of the separator to the dust collecting pipe, which diaphragms are adapted to the necessary air velocity in the dust discharge ducts. The dust collecting pipe is formed with cylindrical bores which are increased in size progressively and in stages from each separator connection to the said pipe, the diameters of such bores being defined according to the quantity of dust-conveying air passing therethrough.

The separator elements are connected to the dust collecting pipe according to the invention by means of a transitional element which is preferably moulded by injection

from synthetic resin or rubber. The group centrifugal dust extractor in which the dust is extracted without the use of a collecting container are especially to be considered where maintenance-free operation of the centrifugal separator is necessary.

The air velocity in the dust ducts and in the dust extraction pipe should advantageously be approximately 8.5 m./sec. at all points along the pipe, so that the dust is carried along in the pipe by the air stream and is not able to settle in the pipe line, as this would lead to clogging of the latter.

As regards the dust extraction pipe, if the separator inlets into the suction pipe were not matched as regards velocity, the air velocity at the end of the suction pipe would be too low because of the tube resistance in the ducts and too high at the start of the suction pipe.

In order to balance out the air velocity in the dust discharge ducts of the separator and in the dust extraction pipe, air diaphragms or baffles for balancing the air velocity are provided in the duct pipe of the separator.

This balancing is shown diagrammatically in Fig. 4. Embodiments of the centrifugal dust separator assembly according to the invention are shown by way of example in Figures 1 to 4.

Figure 1 represents an assembly consisting of a single element, in which 1 represents the vortex chamber, 2 the dust collecting container, 3 the distributor in the form of a turbine wheel, 4 a centering ring, 5 the dust outlet slot of the vortex chamber and 6 the clean gas discharge duct.

Figure 2 represents a separator group consisting of two separator elements. In this figure, 7 represents the vortex chamber, 8 the common dust collecting container, 9 the turbine-like distributor with intake apertures 9*a*, while 10 is the clean air outlet pipe, 11 the dust outlet slot and 12 the pressure equalising hole in the middle of the base of the vortex chamber.

In the embodiment according to Figure 2*a* (left) the pressure equalising aperture 12 is surrounded on the inner side of the vortex chamber by a ring of blades 16 covered by a plate 17. In the embodiment according to Figure 2*a* (right) the vortex chamber 7 carries on its base additionally an annular prolongation 18 having an inner groove 19 in which a filter 20 is inserted.

Figure 3 shows a group separator, in which the dust is extracted directly by way of a dust discharge duct from the vortex chamber, the dust being sucked into a dust collecting pipe. The separate vortex chambers are indicated at 13 and these chambers comprise in the bases thereof the dust discharge ducts 14 which open into the dust collecting pipe 15.

Figure 3*a* shows the nozzle-like diaphragm 14*a* by which the diameter of the dust discharge duct 14 is adjusted to a predetermined value.

Figure 4 illustrates diagrammatically the balancing of the air velocity in an assembly corresponding to the embodiment shown in Figure 3.

The matching or balancing of the air velocity is carried out by the air flow at the commencement (stage 1) of the dust discharge suction pipe into the ducts of the separator elements being strongly throttled by reducing the cross-section of the duct by means of interchangeable air diaphragms, while towards the end of the suction pipe, the throttling in the ducts is reduced from stage to stage, so that the full cross-section is obtained at the stage 10.

Since the diaphragm cross-sections cannot be calculated because of the unknown contraction values, the diaphragm cross-sections must be determined by practical experience by measuring the resistance in the pipeline.

As shown in the figure, the dust extraction pipe is for this purpose provided at the start of the pipe with a measuring position which is connected by means of a rubber tube and by way of a U-pipe in each case to the measuring positions on the separator bases.

In order to start the balancing of the air velocity, the bores of the air diaphragms are initially set according to certain initial values in the ducts.

The pressure which is adjusted as the air is drawn through the separator battery at the U-pipes must be at the same level at all separators.

The air diaphragms, which are in the form of a nozzle, must be so matched from one separator stage to the next, if necessary by opening up the bore, that all measuring positions indicate the same pressure level tolerance of ±2%.

WHAT I CLAIM IS:—

1. A centrifugal dust separator assembly, including a number of elements each comprising a cylindrical vortex chamber with an approximately tangential dirty air inlet, in the form of a distributor similar to a turbine wheel, and an axial clean air outlet, and with connected, separate or joint dust collecting containers, the distributor and vortex chamber being made as a die casting.

2. A centrifugal dust separator assembly as claimed in Claim 1, in which the distributor and vortex chamber are connected together by a centering ring, the vortex chamber being provided with a dust discharge slot.

3. A centrifugal dust separator assembly as claimed in Claim 2, in which each vortex

chamber is provided in the base with a pressure equalising hole, the cross-sectional ratio between the dust discharge slot and the pressure equalising hole being 5:1.

4. A centrifugal dust separator assembly as claimed in Claim 3, in which the pressure equalising hole in the vortex chamber is covered by a top plate carried by blades.

5. A centrifugal dust separator assembly as claimed in Claim 3 or 4, in which a filter is connected before the pressure equalising hole in the dust collecting container.

6. A centrifugal dust separator assembly as claimed in any one of Claims 1 to 5, in which the connection of the dust discharge ducts of the separate separator elements to a dust collecting pipe is effected by step-by-step increasing of the diameters of the individual connections.

7. A centrifugal dust separator assembly as claimed in any one of Claims 2 to 5, in which the dust discharge duct is arranged tangentially on the vortex chamber in the direction of the separation vortex.

8. A centrifugal dust separator assembly as claimed in Claim 6, in which the connection of the separator elements to the dust collecting pipe is effected by interposition of rubber-like transitional elements which are injection-moulded.

9. A centrifugal dust separator assembly, substantially as hereinbefore described with reference to any of the embodiments illustrated in the accompanying drawings.

HASELTINE, LAKE & CO.,
Chartered Patent Agents,
28 Southampton Buildings,
Chancery Lane,
London, W.C.2,
Agents for the Applicant.

Abingdon : Printed for Her Majesty's Stationery Office, by Burgess & Son (Abingdon), Ltd.—1963.
Published at The Patent Office, 25, Southampton Buildings, London, W.C.2,
from which copies may be obtained.

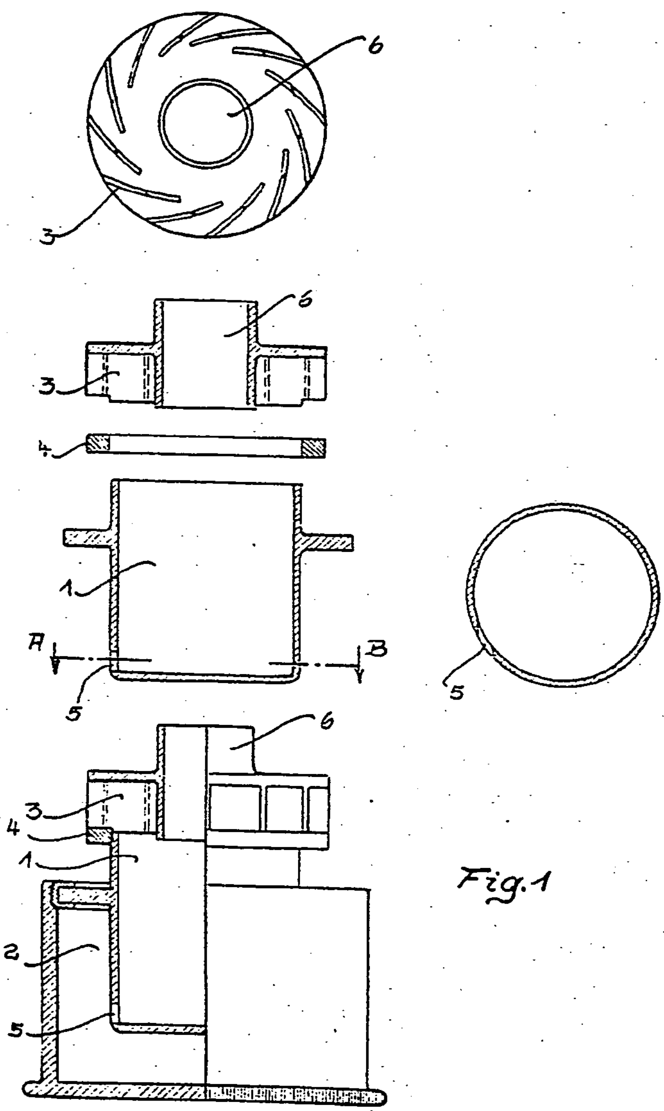


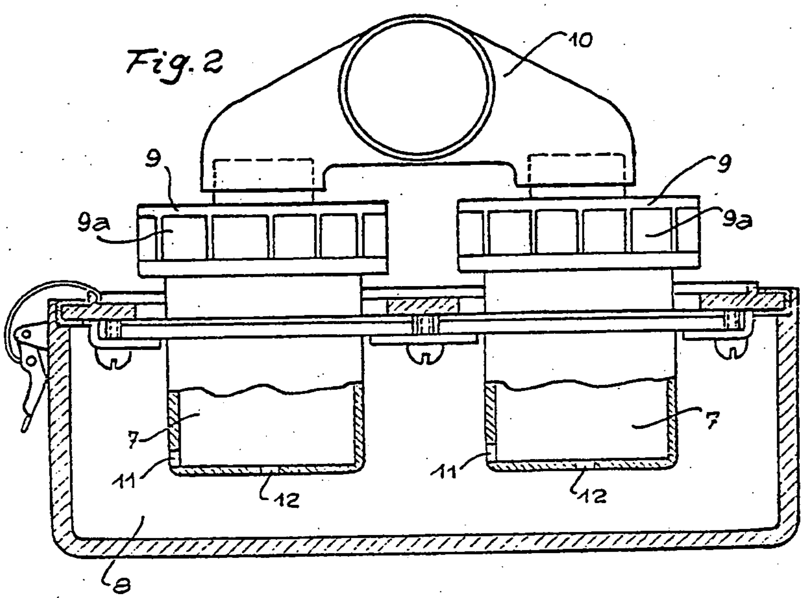
Fig.1

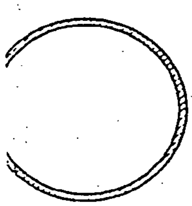
933936 COMPLETE SPECIFICATION

4 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheets 1 & 2

Fig. 2





ig. 1

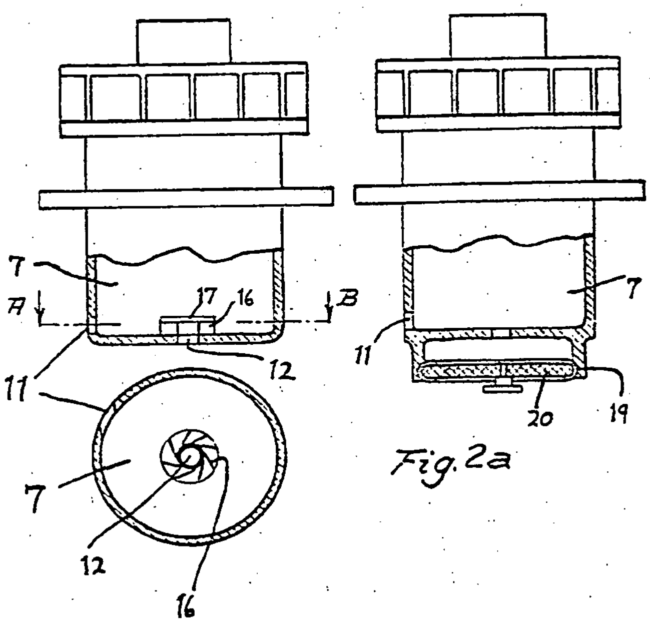


Fig. 2a

933936 COMPLETE SPECIFICATION
4 SHEETS *This drawing is a reproduction of the Original on a reduced scale*
Sheets 1 & 2

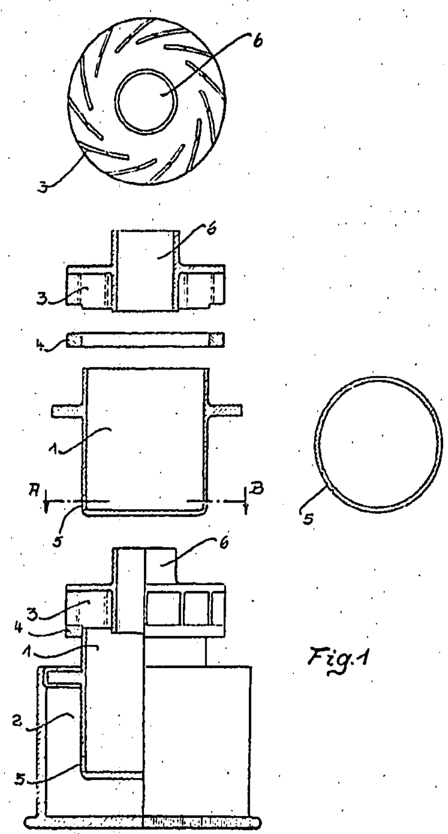
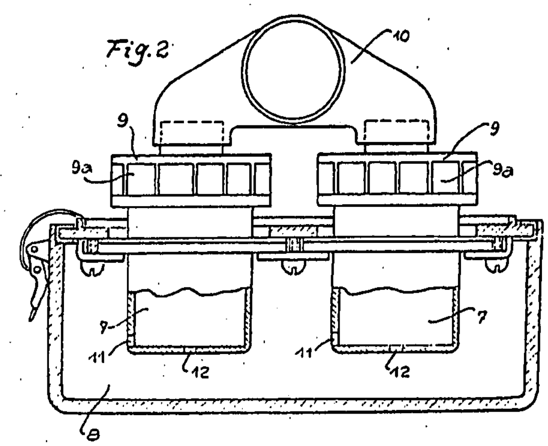


Fig.1

Fig.2



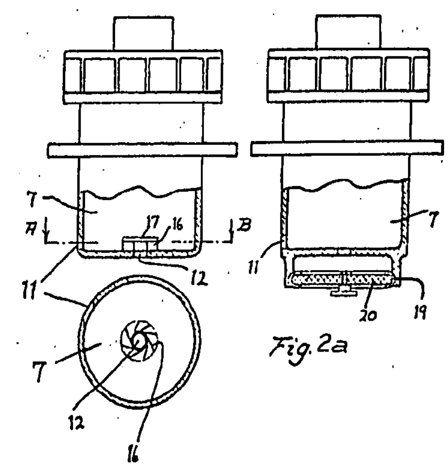


Fig.2a

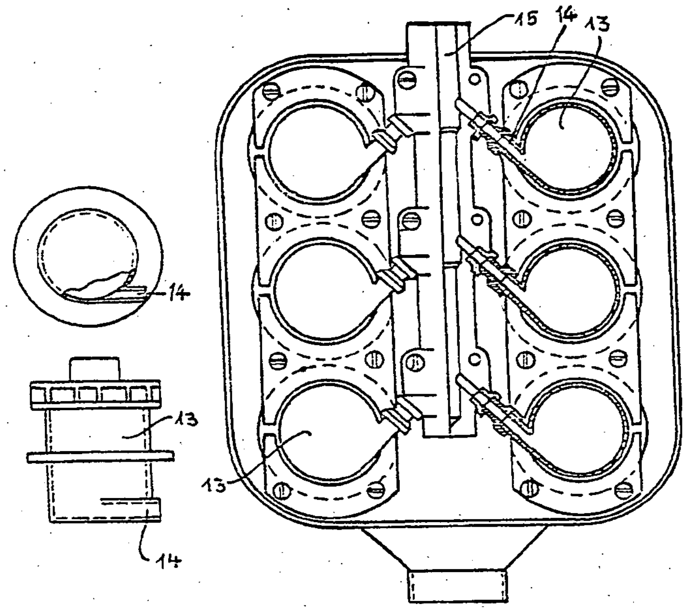


Fig. 3

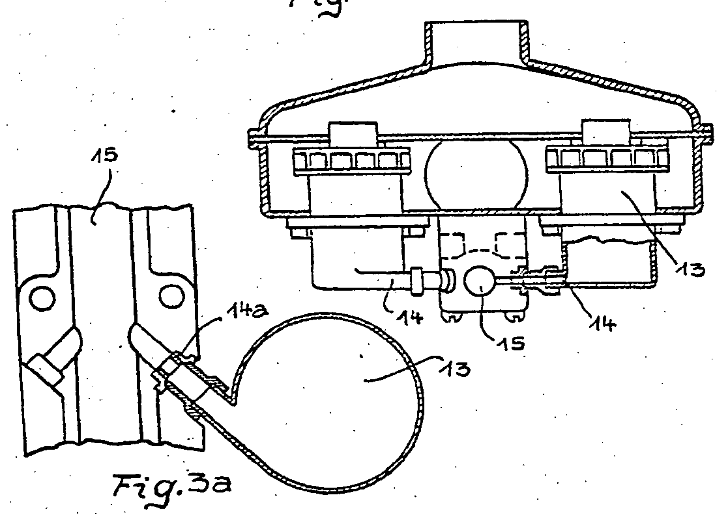
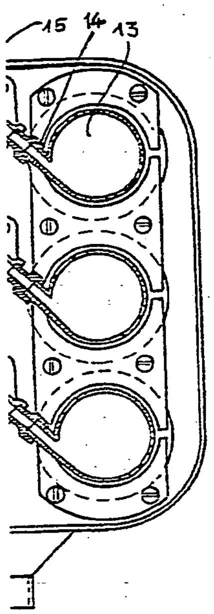


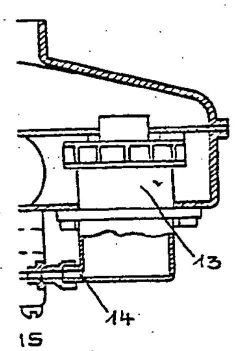
Fig. 3a

933936 COMPLETE SPECIFICATION

4 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheets 3 & 4





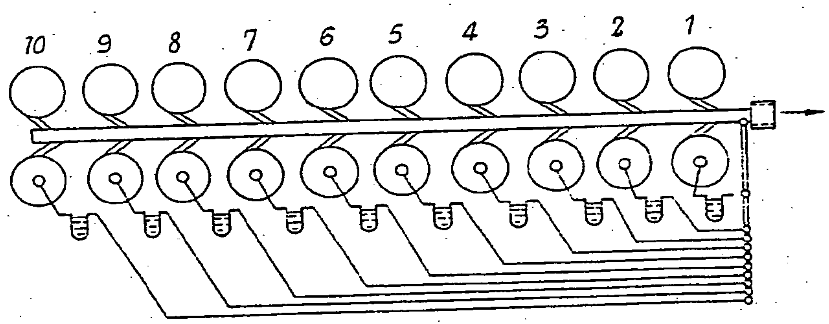


Fig. 4.

933936 COMPLETE SPECIFICATION
4 SHEETS *This drawing is a reproduction of the Original on a reduced scale*
Sheets 3 & 4

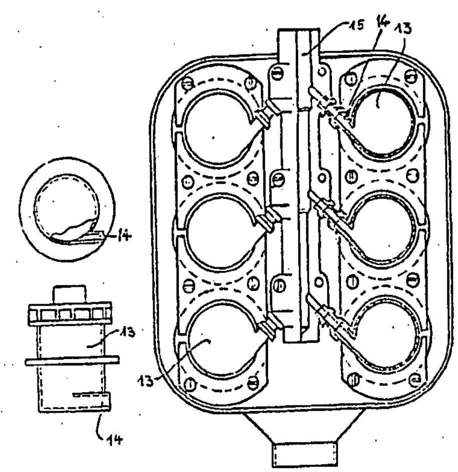


Fig. 3

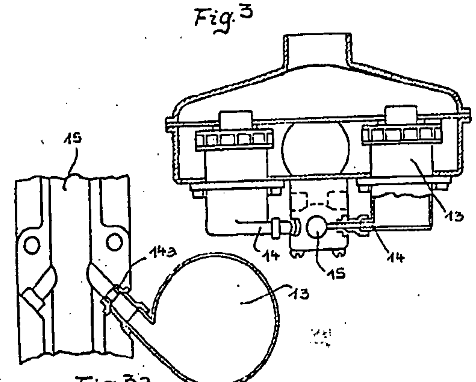


Fig. 3a

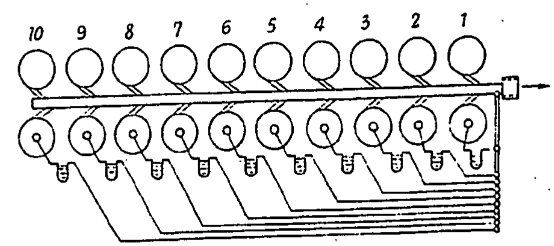


Fig. 4.

THIS PAGE BLANK (USPTO)